University of Hawaii

THE HAWAII GEOTHERMAL PROJECT

PROGRESS REPORT
ON THE DRILLING PROGRAM
May 5, 1976

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FOREWORD

The next few months will be crucial to the development of geothermal energy in Hawaii. The first well to be drilled by the Hawaii Geothermal Project was completed on April 27, 1976, to a depth of 6445 feet. It's a hot well -- the maximum temperature recorded to date is 280°C (536°F), and rising.

It is premature to know whether sufficient permeability exists in the high temperature region to support a geothermal reservoir. However, ERDA has provided an additional $258,560 to install a slotted liner to the full 6445-foot depth and to complete the well testing program. A great deal more information on the commercial potential of the well should be known by the end of June.

The State Department of Land and Natural Resources has been holding public hearings to consider the adoption of a set of Geothermal Rules and Regulations. These regulations, particularly if they incorporate the key revisions that have been suggested, should provide a sound base for developing geothermal resources in the State.

In the section of this progress report on Conclusions and Recommendations, I have taken the liberty of editorializing on the direction that geothermal research and development might take in Hawaii -- including phasing out the HGP at the end of FY 77, and replacing it with a more viable developmental entity. All segments of government and industry in Hawaii must move rapidly and cooperatively in order to assure that geothermal energy assumes its proper role as a State and as a National resource. The HGP will continue to assist in this effort.

John Shupe

John W. Shupe
Director

May 5, 1976

PROGRESS REPORT

FOR THE HAWAII GEOTHERMAL PROJECT

HGP-A

Designation of the well has been switched from HGP Well No. 1 to HGP-A, for Abbott. It was the early intent that should this well become hot, that it would be identified in honor of Dr. Agatin A. Abbott -- who, before his tragic death, had been chairman of the Site Selection Committee responsible for locating the drill site. Subsequent reference to this well will identify it as HGP-A.

Drilling was completed for HGP-A at 6,445 feet on April 27, 1976. The hole was immediately logged with Gearhart-Owen equipment from 3500 feet to the bottom of the production casing at 2222 feet. A core was then drilled to a depth of 6455 feet; and the drill stem was withdrawn and layed down on the site adjacent to the rig -- as a safety measure against possible volcanic tremors. This completed the drilling-coring-logging program for HGP-A.

Prior reports have documented the difficulties encountered in the early drilling, hole opening, and casing phases. Once the production casing was set at 2222 feet, subsequent drilling progressed rapidly for the remainder of the well. The bottom 4200 feet was drilled in less than three weeks -- from April 6 to April 27 -- with a total of five days of that time devoted to logging and coring; so an average drilling rate of 270 feet per day was achieved over the lower two-thirds of the hole.

WELL CONDITIONS

The well is a hot hole, with temperatures easily within the range of commercial power generation. However, it is premature to know whether there is sufficient permeability to permit a geothermal reservoir to exist. It is

possible that only hot, essentially dry rock is present.

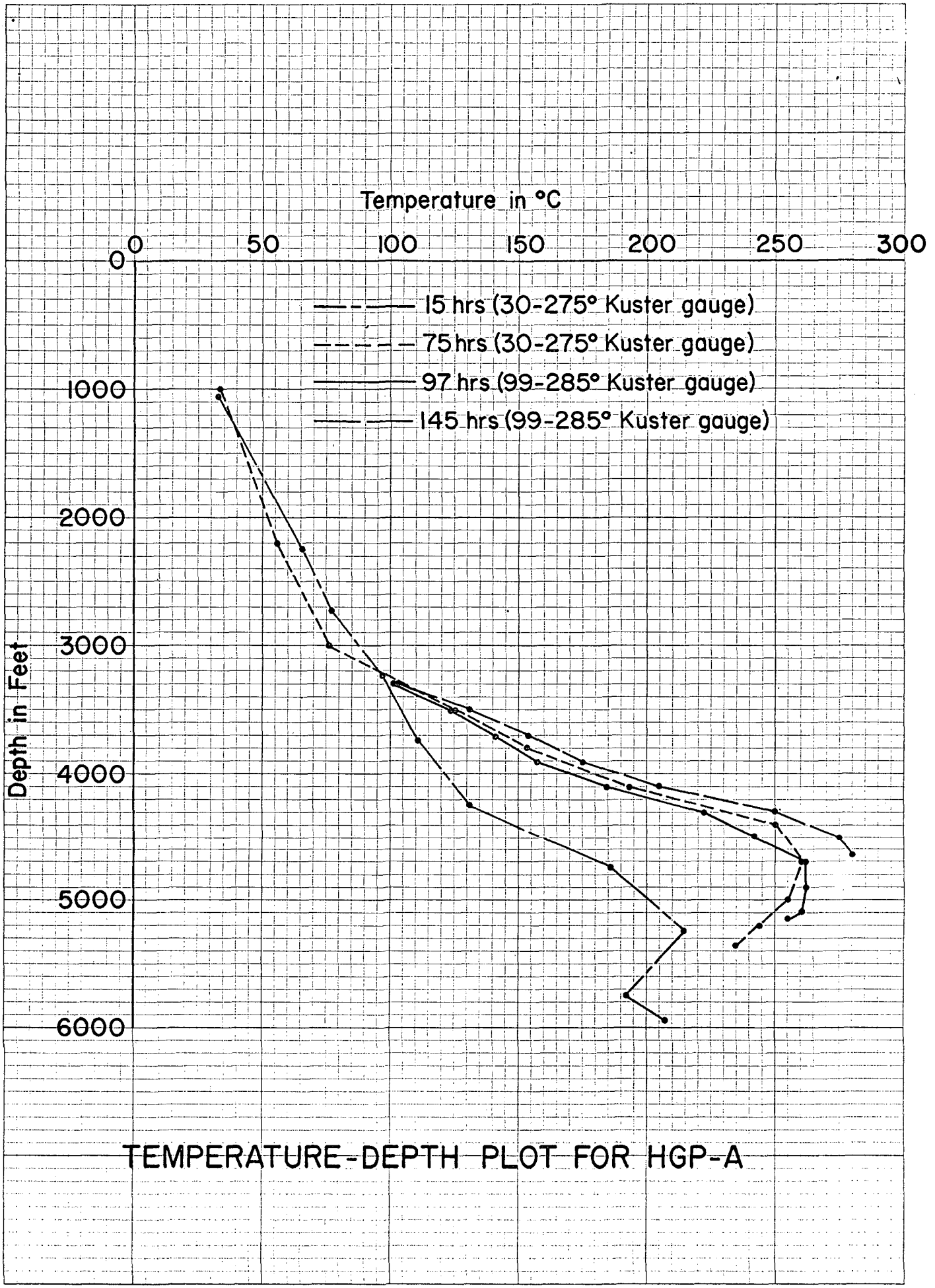
Initial efforts to obtain an accurate downhole temperature measurement below 6000 feet were thwarted when the Gearhart-Owen equipment lowered into the hole encountered a temperature of 311°F at 3970 feet. Since the upper limit of this equipment is 300°F, it was withdrawn. It has been impossible to obtain a logging run below 3500 feet, due to the rapid buildup of temperature when mud circulation ceases.

Temperature runs with Kuster equipment have been recorded at 15, 75, 97, and 145 hours after mud circulation was terminated. A record of these four temperature runs is shown in Figure 1. Two different temperature sensing devices have been used, providing some check on reliability of measurement. The maximum downhole temperature recorded to date is 280°C (536°F) at 4660 feet. The initial temperature run went to 5950 feet, which was the total length of the cable. Subsequent runs at 75, 97, and 145 hours were limited to 5350, 5170, and 4660 feet, since the weighted probe would penetrate no deeper into the mud, which apparently is hardening.

PERFORATING AND CEMENTING

When the cement bond log was run, it was discovered that two sizeable voids existed between the production and the anchor casings at depths from 40 to 220 feet and from 320 to 868 feet. If this condition is not corrected, when the casing heats up from the geothermal fluid flowing in the hole, the vapor pressure built up in the voids can collapse the production casing inward, blocking flow. Differential thermal stresses can also be created that destroy alignment of joints and can result in casing failure. Therefore, this condition must be corrected before the drilling mud is removed, and the hole allowed to heat up.

This is not an uncommon condition to occur during a drilling and cementing program, and there are companies such as Halliburton and Gearhart-Owen which



TEMPERATURE-DEPTH PLOT FOR HGP-A

have the special equipment for perforating the inner casing and forcing cement into the voids. It is estimated that three days of rig time, plus charges for bringing the special equipment and operators to Hawaii will be required for this task.

SLOTTED LINER, WELL HEAD, AND AUXILIARY EQUIPMENT

Due to the nature of the fractured basalt and to the frequent strata of poorly consolidated materials, there is concern that the sides of the well will cave in when the drilling mud is removed and the walls conditioned for well flow measurements. Therefore, it is essential to install a slotted liner below the 9 5/8-inch production casing, which was cemented in at 2222 feet, before proceeding with the testing program.

The liner to be installed has a 7-inch outside diameter. Every third section will be slotted with 2 1/2 x 1/2-inch holes on 6-inch centers, 16 slots per foot. These slots will permit any geothermal fluid to flow into the casing, but will maintain stability of the walls.

Approximately seven days of rig time are estimated to condition the drilling mud, go in and out of the hole, run in the slotted liner, wash out the mud, complete initial well tests, and install the wellhead and auxiliary equipment.

WELL TESTING AND ANALYSIS PROGRAM

Now that it has been demonstrated that a temperature exists that is well within the range required for the generation of electricity, a comprehensive well testing program is warranted. The program to be followed is that developed by KRTA and described in detail in their publication, "Testing Program for the Hawaii Geothermal Project". In summary the purpose of the testing program is to:

1) Assess the underground reservoir for possible exploitation.

2) Assist in the understanding of future exploration programs.

3) Help establish target depths for subsequent drilling.

4) Establish engineering design requirements, including the safety of equipment and personnel.

5) Investigate potential environmental hazards during operation.

6) Establish criteria for plant operation.

The well testing and analysis program will be divided into two sequential phases:

1) Static test: After the liner is installed and the well flushed, downhole temperature, pressure and water samples will be obtained to determine fluid conditions. Pumping tests will then be initiated to test for reservoir permeability.

2) Flow test: A combination of lip pressure and wellhead separator measurements are needed to determine flowrate and cumulative flow. Downhole temperatures must be taken for enthalpy and downhole pressure for drawdown and buildup tests. Wellhead temperature and pressure should also be recorded to measure wellbore losses. It is anticipated that a minimum of thirty days will be required for the flow test phase.

WELL MONITORING DURING STANDBY

It will require about three and a half weeks to get the slotted liner delivered to the site. During that period the well must be monitored daily for temperature and mud level to assure that it does not heat up excessively and cause casing collapse before the perforation and cementing job is completed. Also, around-the-clock security must be maintained.

WRI has agreed that no standby charge will be made for its rig during this period, even though it may be necessary to add mud on occasion. However, one person from the crew will be kept at the site at all times, and daily monitoring of temperature and mud level will be conducted by either Bill Craddick or Clarence Mason, the two rig superintendents. Also, at least one additional Kuster temperature run will be made, with assistance from WRI personnel.

ENVIRONMENTAL ASSESSMENT

Baseline environmental studies will be completed and analyzed. This will

include findings on the effect of the geothermal well drilling on the soil, plant life, and ground water near the drill site, as well as a statement of the potential effects (negative) on the indigenous bird life and archeological sites in the area.

A prototype environmental impact statement will be drafted to include not only the foregoing physical data, but also considerations of socioeconomic impact. The prototype EIS would be applicable to this well, if developed for production, or to any geothermal production in the Puna area.

The total projected budget for personnel, travel, and supplies is $13,200. However, with carryover funds from the existing budget, only $3000 of supplemental funding is required.

PROJECTED TIME SCHEDULE AND BUDGET

The slotted liner has been ordered, with delivery in Honolulu "assured" on May 23. The crew will be mobilized on May 24 to begin the estimated three days of perforating and cementing to fill the two voids. This will be followed by installation of the slotted liner and well head equipment. Well testing should commence by the second week in June and continue through the remainder of the summer, as will the environmental baseline studies and the prototype EIS.

The funding required to complete preparations and implement the well testing programs is estimated at $258,560 -- as itemized in the attached budget summary.

CURRENT STATUS OF FINANCIAL SUPPORT FOR THE HGP

ERDA has been quite responsive to the additional financial requirements brought about by recent developments in HGP-A. It was determined before drilling had progressed to 1500 feet that the original $979,000 allocated from ERDA and State funds for the drilling subcontract would be inadequate to

HAWAII GEOTHERMAL PROJECT

ESTIMATED BUDGET TO COMPLETE WELL TESTING PROGRAM

April 30, 1976

A.	Perforate & Cement to Establish Adequate Cement Bond:		
	1) Rig time (3 days)	$18,000	
	2) Perforating, tools & oper.	4,000	
	3) 5 runs with RTTS tool	4,000	
	4) Misc. tools, freight, & operation	5,000	
	5) Handling charges	3,000	
	Subtotal		$ 34,000
B.	Install Slotted Liner, Wellhead, & Auxiliary Equipment:		
	1) 4500' of 7" liner, 1/3 slotted	46,000	
	2) Rig time (7 days)	42,000	
	3) Valves, gauges, & misc. equip.	37,500	
	4) Handling & purchase charges	8,000	
	Subtotal		133,500
C.	Well Testing & Consulting:		
	1) Personnel (KRTA & UH)	14,900	
	2) Equipment - sampling bottle, separators, etc.	17,700	
	3) Travel & expenses	4,560	
	Subtotal		37,160
D.	Monitoring and Miscellaneous:		
	1) Monitoring & security during downtime	15,300	
	2) Demobil. & mobil. of crew	5,000	
	3) Final demobilization of rig	9,600	
	4) Servicing & storage of government equip.	1,000	
	Subtotal		30,900
E.	Environmental Baseline Studies and Prototype EIS		3,000
F.	Contingency		20,000
	TOTAL		$258,560

complete the well to the target depth of 6000 feet. On March 18, 1976, an estimated deficit of $257,000 was projected and efforts were successful in identifying this amount -- $150,000 was provided by ERDA; $60,000 from Water Resources International (WRI); and $47,000 shifted to drilling from the research and support budget provided by ERDA, the State, and Hawaiian Electric Company. These funds were sufficient to complete the hole to 6445 feet, as well as the associated coring and logging programs. Once the high downhole temperature was encountered, efforts were initiated to identify additional funding to continue with a comprehensive well testing program.

A meeting of the ERDA Geothermal Coordinating Group was scheduled in Idaho Falls for April 27-28, at which the HGP Director was invited to present a report on HGP-A. The timing was ideal, since nearly all of the key staff from ERDA's Geothermal Division were in attendance -- Eric Willis, Louis Werner, Ronald Toms, and John Salisbury. Based on discussions with this group and a series of follow-up telephone calls, $85,000 was released immediately with which to purchase the slotted liner and well head equipment, while approval was obtained for the additional $173,560, as soon as it could be transferred from Washington through the San Francisco Projects Office to the HGP.

Also while in Idaho Falls, tentative approval -- contingent upon a satisfactory proposal -- was received from ERDA for an additional $300,000 through fiscal year 77, with which to follow up on the scientific information and correlations to be obtained from HGP-A.

CONCLUSIONS AND RECOMMENDATIONS

The following observations and comments are editorial in nature on the part of the HGP Director and do not necessarily reflect the opinion of his colleagues on the HGP. These viewpoints have been developed through a long series of discussions with officials of federal funding agencies and were

reinforced by the recent meeting with ERDA staff at Idaho Falls.

1. ERDA, and its predecessor NSF-RANN, have consistently supported the HGP. A total of $2,060,000 in federal funding has been received for the project, and the last two segments from ERDA totaling $408,560 have been particularly responsive to emergencies that have arisen in the drilling and testing programs. The $300,000 tentatively committed by ERDA through FY 77 to complete the correlation, analysis, and synthesis of all scientific data as it relates to actual subsurface conditions should nicely round out the initial phase of the investigation.

2. Subsequent support from ERDA, particularly for additional drilling in Hawaii, will be difficult to come by -- for at least three reasons:

a) ERDA is concerned over the degree of national significance and relevance of geothermal research and development in Hawaii. (The HGP could and should make a much stronger case for this spin-off in subsequent reports and proposals. The fact that Republic Geothermal, Inc. is flying three of its top men to Hawaii just to discuss the drilling aspects of HGP-A alone suggests that there is a much higher level of national spin-off to the project than is realized.)

b) ERDA is concerned over the concentration of geothermal support that has come to this one geographical area -- and that out in the middle of the Pacific. Over and above the $2,060,000 in federal funding awarded to the HGP to date, and the probable $300,000 of additional funding through FY 77, Dr. George Keller of the Colorado School of Mines also received over $700,000 from NSF-RANN to drill an experimental geothermal well near the summit of Kilauea. As expressed by one ERDA official, his organization has received requests for funding for geothermal drilling at over a hundred different locations, and it will be difficult to justify support for a third Hawaiian well.

c) ERDA is concerned over funding developmental projects through universities. It is ERDA's policy to work closely with the "real world", as represented by industry and possibly by other levels of government, in application projects, rather than with the sheltered environment of a university.

3. Consideration should be given to dissolving the HGP at the end of FY 77, when the follow-up studies on HGP-A are completed. Both NSF-RANN and ERDA have had difficulty in evaluating and funding these broad multidisciplinary proposals submitted by the HGP, and the current climate is probably more favorable for submission of proposals which shift the program planning aspects from the HGP to ERDA.

4. This does not mean that unsolicited proposals for geothermal research from UH would cease, only that they would go in as separate distinct proposals to a specific program within ERDA's Geothermal Division. Particularly now that a broad base of technical expertise has been established at the University and the potential for a conventional geothermal resource begins to look encouraging, proposals should be forthcoming in geophysics, hydrology, energy conversion, reservoir engineering, well testing, education of trained personnel, and hydrofracturing -- if HGP-A has discovered hot dry rock, rather than a hydrothermal system.

5. An essential corollary to dissolving the HGP is to establish immediately a State-industry-University consortium, as proposed by the HGP Director over a year ago. This would provide a creditable entity with which ERDA could interact in the development of geothermal power for Hawaii. Hideto Kono, as State Energy Resources Coordinator, should take the lead role in establishing this consortium, with representation from his Department of Planning and Economic Development, the Department of Land and Natural Resources, County Government, and the University. The Hawaiian Electric Company also should be included, as well as a geothermal planning-support group, such as Republic Geothermal, Inc. or TRW. Certainly an appropriate role for GEDCO should be considered.

6. This consortium -- it might have some such title as the Hawaii Geothermal Resources Authority -- should begin to plan and to implement a coordinated program of geothermal research and development for the State. Of immediate concern is what to do next if HGP-A is a successful potentially producing well. Certainly additional wells on Hawaii and an expansion of the drilling program to Oahu, possibly beginning with shallow holes, should come under early consideration. This consortium should move rapidly to develop a 5 to 10 megawatt demonstration plant, ideally with participation by ERDA.

7. The early goal of the HGP to establish a National Geothermal Laboratory for volcanic regimes should be pursued aggressively. This concept was endorsed by the first NSF program manager, Dr. Raymond Zahradnik, and received strong support from ERDA's original program manager, Dr. Paul Kruger. However, the current climate in ERDA is not favorable to establishing such an institution in Hawaii, with much of the reservation relating to the national relevance issue. If a viable geothermal resource is discovered on the Big Island, the timing would be excellent to mount a strong campaign for establishing a National Geothermal Laboratory in Hawaii.

8. Any effort to establish such an institution should have the strong backing both of the State and of Hawaii's congressional delegates. The Idaho National Engineering Laboratory, recently set-up by ERDA, owes its creation in no small part to the political support provided at both the State and the National levels. The Memorandum of Understanding signed last month by ERDA and the State of Hawaii may provide the appropriate vehicle for initiating action on a Hawaii National Geothermal Laboratory for volcanic regimes.